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Abstract

THE METHOD OF MAIN PARAMETER DETERMINATION OF HEAVY WATER GAS COOLED POWER REACTOR CORE

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The presented paper describes the method and results of optimization calculations of heavy water power reactor core parameters. The method is based on the complex optimization of parameters from the point of view of main technical and economic indexes of an industrial power station.

Direct application of final optimization criteria concerning the whole power station in concrete applications restricts the choice of sufficient number of independent variable paramaters of reactors, primary and secondary circuits.

The analysis of general relations for useful power and net efficiency of the power plant leads to the determination of objective partial criteria for optimization of some active zone parameters. In many cases these criteria facilitate the judgement of specific problems connected with the design of the reactor.

It is possible in first approximation to use the criterion of the maximal effective fuel charge for optimization of the power reactor active zone arrangement. The effective fuel charge is expressed in the following:

$$U_{ef} = \frac{\Sigma \; u_i \; i}{\phi_{max}} \qquad \text{(summation over the whole volume of fuel)}$$

where: u_i is the section of reactor fuel irradiated by thermal neutron flux ϕ_i.

For the fixed heat rate of a fuel element irradiated by the maximum thermal neutron flux and determined heat removal conditions is the thermal and useful power of the reactor determined by the effective fuel charge.

The dependence of the effective fuel charge on geometrical parameters of the fuel element (the diameter and relative fuel element filling defined as ratio of uranium volume to fuel element volume) is searched for the one region core without reflector with various values of geometrical buckling of the assembly.

For practically available diameter range of fuel elements is the effective fuel charge only slightly variable. Therefore the variation of the fuel elements diameter can be adapted for design requirements or used to radial flattening of thermal neutron flux in a way as used in this paper.

For the specified type of fuel elements with determined fuel channel construction the effective fuel charge is increasing with increasing fuel element filling. But fuel element filling is one of main parameters which determine thermokinetical and hydrodynamical characteristics of the reactor, consequently it is necessary to determine it on the basis of the complex optimization. The results of these calculations for variable parameters as the gas flow, the heat exchanger outlet temperature of gas and the height of active zone enable to do important conclusions for the choice of the fuel element filling parameter.

The radial flattening of thermal neutron flux is effective means for increasing effective fuel charge. Two ways were followed: the flattening by means of fuel element having various diameters arranged into 3 regions and flattening caused by diminishing the moderator to fuel volume ratio in the central region when using press up elements and convenient combination of fuel elements having various diameters. For this case the possibility of peak xenon poisoning reactivity compensation by means of press up elements was assumed. The value of radial flattening coefficient 0.85 for optimum variant was reached.

Two group modified calculation method was used to determine critical dimensions and neutron flux distribution for multiregion core with multi-region reflector. Calculation of great number of variants was carried out using the small digital computer National Elliott 803 B. For this purpose the method was verified to be sufficiently accurate with satisfying time requirement for numerical solution. The computational program is expressed in Elliott-ALGOL language. In addition to possibility to determine critical dimensions and neutron flux distribution the program enables to compute reactivity changes for varying any of parameter in separate regions of the reactor.